TIROS I OBSERVATIONS OF ICE IN THE GULF OF ST. LAWRENCE*

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[Manuscript received June 7, 1960; revised June 21, 1960]

ABSTRACT

TIROS I pictures of the Gulf of St. Lawrence, taken during the first days after launch, have clearly revealed areas of ice. The ice patterns found in two series of pictures are mapped. Also shown are aircraft observations of ice made a week earlier and a week later. The results indicate that observations from satellites might contribute to ice surveys.

The first series of photographs taken by TIROS I on April 1, 1960, showed the Gulf of St. Lawrence and its environs. H. Wexler noted gray areas in the Gulf and in the St. Lawrence River which appeared to be ice. At his suggestion an investigation of satellite pictures of this area has been conducted to map the ice and to compare the results with observations made from aircraft by the Canadian Meteorological Service. It was hoped that the results of this study might form the basis for further investigation of the feasibility of utilizing pictures taken from satellites for ice surveys over the water areas of the world.

*This work was supported by the National Aeronautics and Space Administration.

On April 2 a sequence of narrow-angle pictures was obtained which showed most of the Gulf. A third series,

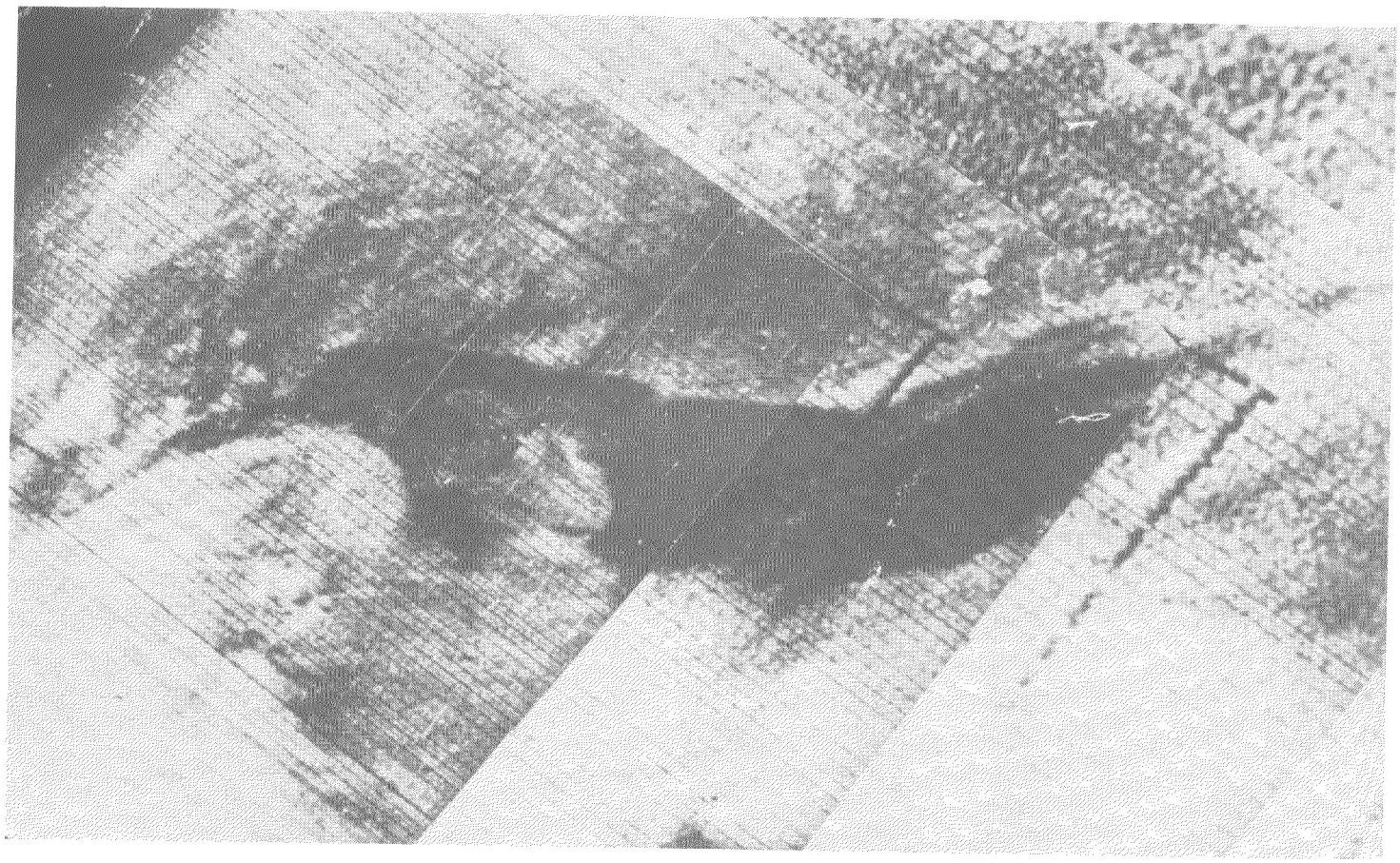

FIGURE 1.—A composite of TIROS I wide-angle photographs taken on April 1, 1960, showing the Gulf of St. Lawrence and environs.

FIGURE 2.—A composite of TIROS I narrow-angle photographs taken on April 2, 1960, showing portions of the Gulf of St. Lawrence and environs.

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taken with the wide-angle camera, as was the original series, also showed the Gulf, but from a greater distance. This time-sequence of pictures over 48 hours has allowed deductions not possible from a single series.

Figure 1 shows a composite of wide-angle photographs taken at about 1500 GMT on April 1. Labrador and Quebec are seen as the gray area in the upper part of the photograph; Newfoundland is on the right; the St. Lawrence River is on the left; the lower part is cloud cover over the southern half of the Gulf. The Gaspé Peninsula and Anticosti Island can be distinguished. The synoptic map at this time showed a large high pressure system in northern Canada centered over Hudson Strait. A frontal system ran south of the High through a weak Low over southeastern Newfoundland, then southwestward through another weak Low off the New England coast. New Brunswick, the lower part of the Gulf, and most of Newfoundland were overcast, while the southern shore of Quebec Province reported mostly scattered clouds. From figure 1 it can be seen that the northern part of the Gulf was clear.

The dark areas are mainly water, while the light areas are mostly land or clouds. In the upper right-hand corner is the Strait of Belle Isle between Labrador and Newfoundland. The grayness in the Strait indicates that it is probably ice-covered. Extending southwestward from the Strait, parallel to but off the coast, is another thin streak of ice which broadens. The main band continues parallel to the coast to the northeastern shore of Anticosti Island, and a branch extends southward between Anticosti Island and Newfoundland to the edge of the clouds. A bright patch can be seen around the eastern end of the island and another just south of the island blends with the clouds. A U-shaped ice pattern can also be readily identified jutting into the St. Lawrence River from the northern coast of the Gaspé Peninsula. Other patterns of ice can be seen just south of the Strait of Belle Isle near Newfoundland.

Figure 2 is a composite of narrow-angle pictures taken at about 1430 GMT on April 2. Newfoundland is on the right; Anticosti Island is in the upper center; the Gaspé Peninsula and the St. Lawrence River are in the lower left. Approximate latitude and longitude lines are shown. The front of the previous day had moved well out to sea, and a high pressure ridge extended southward from the High in northern Canada. The lower St. Lawrence River, the Gulf, and Newfoundland were almost cloudless.

This composite consists of pictures read out directly from the satellite when it was close to the horizon of the monitoring station. The angle of view is quite oblique,

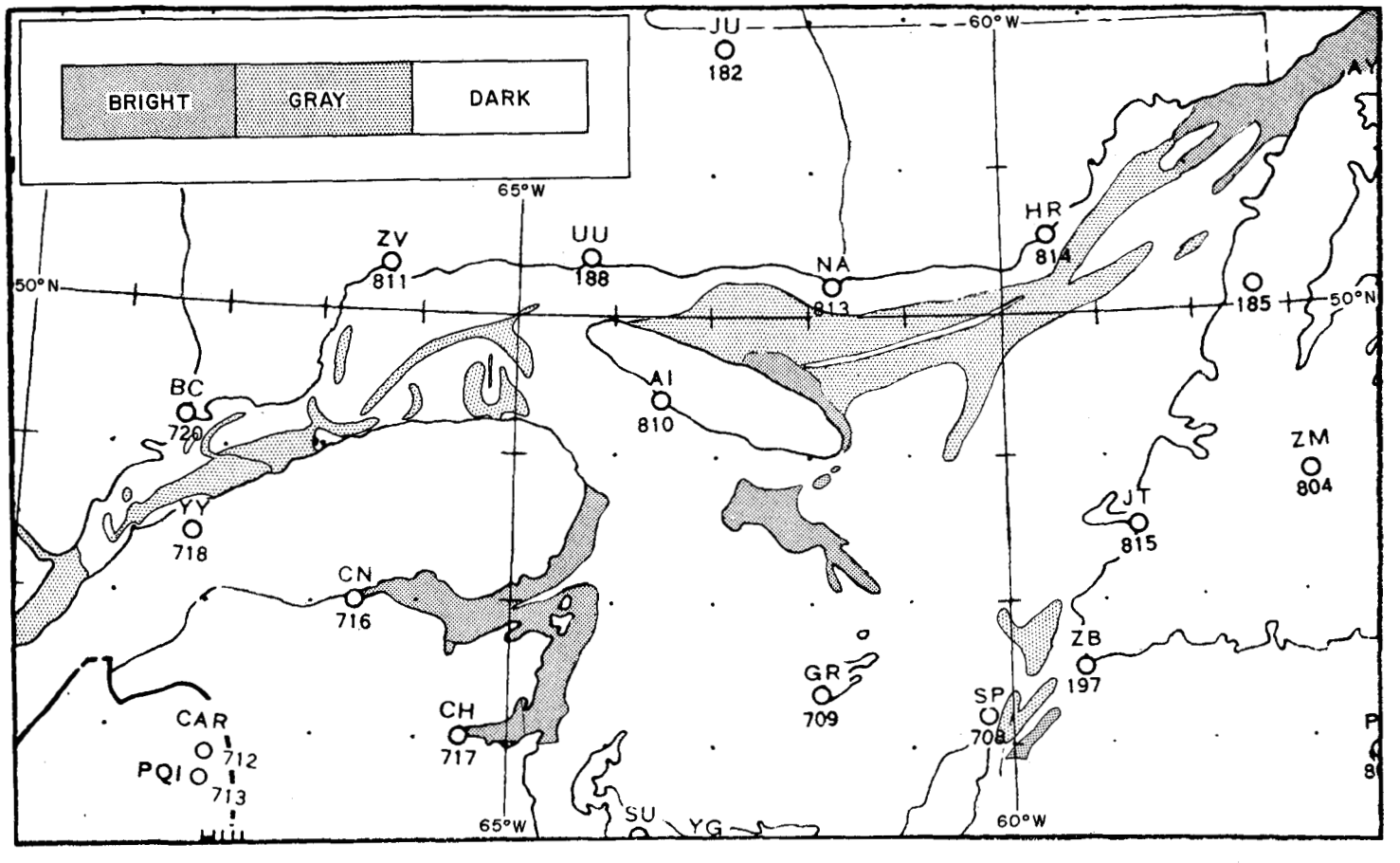

FIGURE 3.—Analysis of ice shown in figures 1 and 2.

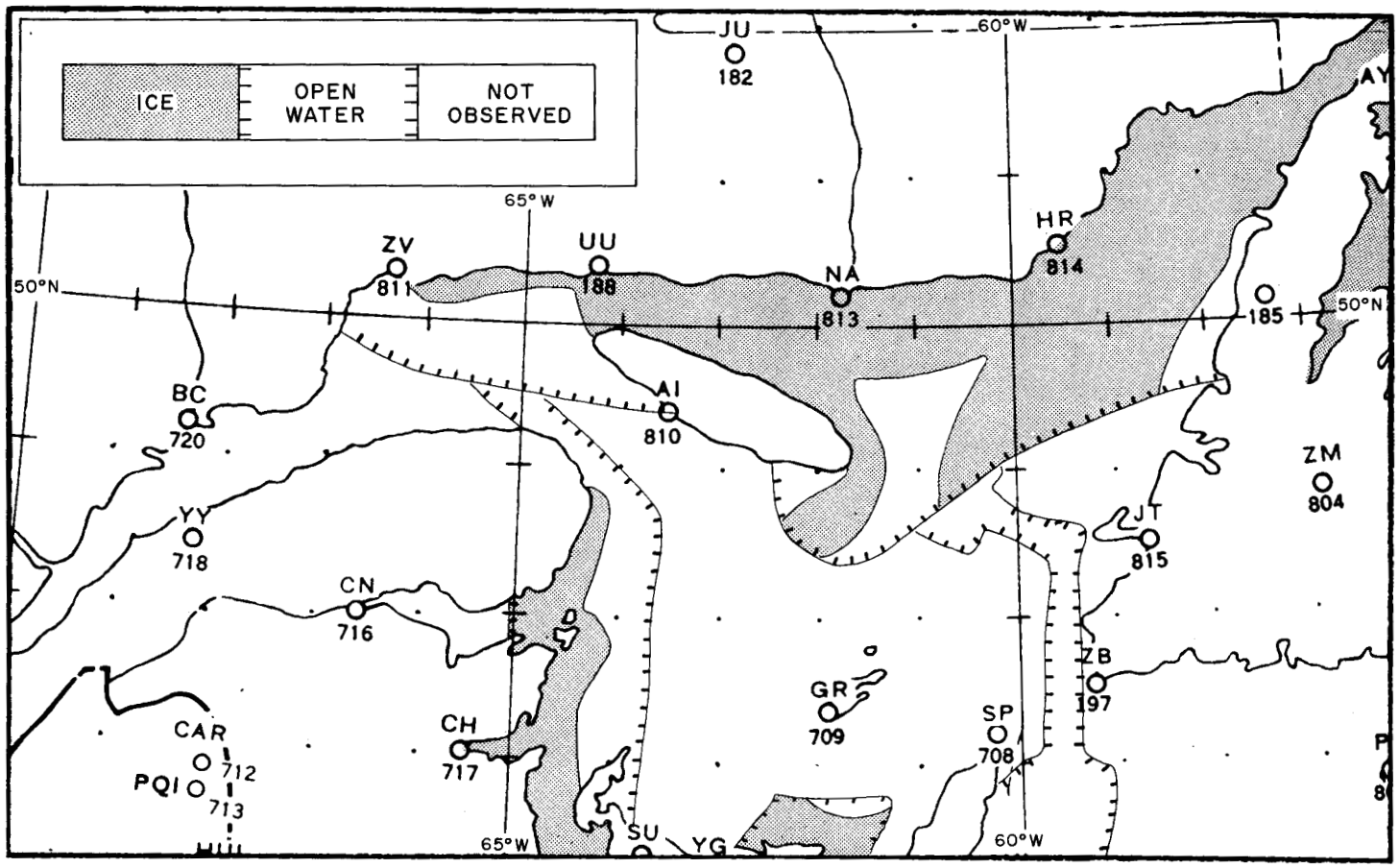

FIGURE 4.—Canadian Meteorological Service aircraft observations of ice on March 23 and 26, 1960.

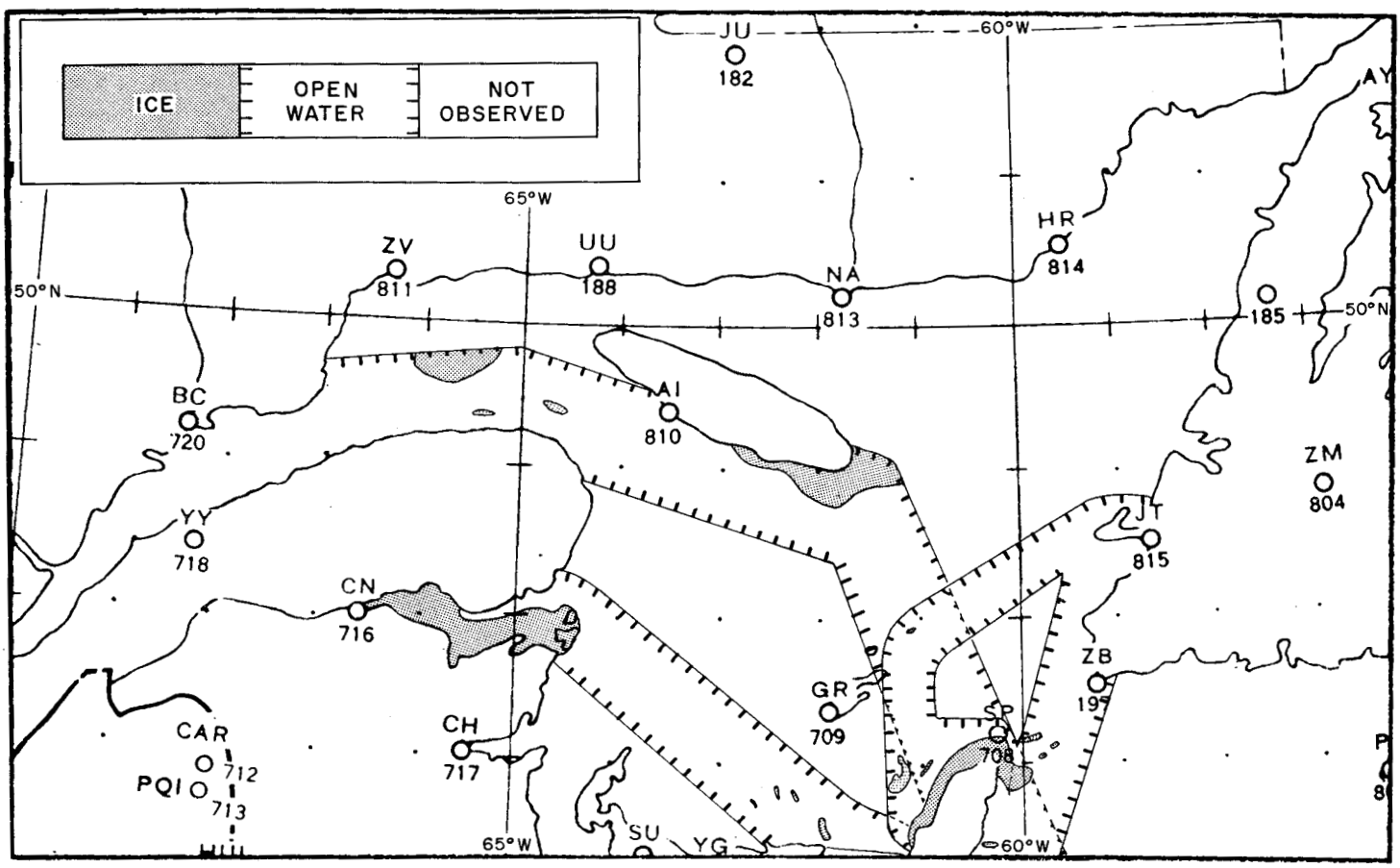

FIGURE 5.—Canadian Meteorological Service aircraft observations of ice on April 6 and 7, 1960.

resulting in considerable foreshortening, as indicated by the shapes of the Gaspé Peninsula and Anticosti Island. One of the most interesting features in this picture is the large bright patch just south of the island, which is believed to be a large ice floe that has broken away from a pack along the island, carried south by the persistent northerly winds. The general configuration of the northern portion of the floe seems to support this hypothesis. Although not so clear as in figure 2, the floe is also evident in figure 1 and on the pictures taken on April 3, not shown here. There appears to be dense, probably pack, ice on the lower northeastern shore of Anticosti Island, while loose ice exists along the upper part of this shore. Near the upper edge of figure 2 at about 60° W., is the southern tip of the band of ice seen in figure 1 to extend southward between Anticosti Island and Newfoundland to the clouded area. The St. Lawrence River from the city of Quebec (not visible, but near the extreme lower left corner) is partially obscured by a thin layer of cirrus clouds, which ends about 80 to 100 miles northeast of Quebec. From there to about 49° N. the river is more clearly visible, with loose ice appearing in indistinguishable patterns. Beyond this point and along the northern coast of the Gaspé Peninsula the ice appears in more dense, curved streaks. From Gaspé Bay southward toward Miramichi Bay the shoreline appears highly reflective. Chaleur Bay looks ice-covered, except near the entrance. Part of Gaspé Bay appears to be open water. Some elongated streaks appear off the southwestern tip of Newfoundland, including one bright streak. The rest of the Gulf contains a few less clearly visible, more diffuse patterns.

Figure 3 shows an analysis of the water areas in the Gulf of St. Lawrence, derived from the satellite information contained in figures 1 and 2. The dense dots indicate areas of high reflectance and, presumably of highly reflecting ice; the open dots indicate gray areas, which are presumed to be ice areas of medium reflectance; unmarked areas appear dark and are interpreted as open water or ice areas of very low reflectance.

Figure 4 shows ice conditions as observed on March 23 and 26 from Canadian aircraft. No attempt was made in this figure to distinguish the type or the density of ice; only open water or ice have been shown. The boundaries of the observed areas are indicated. The anvil-shaped area of open water east of Anticosti Island was observed by the satellite, as shown in the analysis and in figure 1. The ice along the southeastern tip of the island may be associated with the floe seen in figure 2. The northern part of the Gulf was almost entirely ice-covered on March 23. Observations on the 26th showed considerable ice along the eastern tip of the Gaspé Peninsula, in Chaleur Bay, and southward along the New Brunswick coast. Open water was indicated off the southwestern part of Newfoundland, then northwestward toward Anticosti Island.

Figure 5 shows aircraft-observed ice conditions on April 6 and 7. Most of the area observed on these days was open water, although some ice still remained in Chaleur Bay, on the southeastern tip of Anticosti Island, and in scattered patches along the path of observation. Much of the area observed on April 7 was outside the satellite photographs.

The sensitivity of the television of TIROS I has been set to render the best reproduction of clouds. It is possible that one might prefer greater sensitivity in order to reveal ice areas which are nearly as dark as the water. In the present case it has been found that the range of grayness extends from white down to the noise level of the system. A greater sensitivity might reveal more of the ice of low reflectance while permitting ice of higher reflectance to appear to be white.

On the other hand, these pictures have been taken under unfavorable circumstances, looking at very oblique angles. Pictures taken in the vertical are generally much superior and would reveal more.

It should be mentioned that the problem of distinguishing between ice and clouds is not severe. The existence of pictures on three days has permitted a positive identification of the large floe as ice rather than cloud. A satellite is capable of at least daily observations and only persistent thick clouds should limit knowledge of ice conditions. Ice can definitely be observed in photographs from satellites and it is hoped that in the future satellites can contribute to ice surveys.

ACKNOWLEDGMENT

We thank the Director of the Meteorological Service of Canada for furnishing the ice survey charts, and also members of the Division of Oceanography, U.S. Navy Hydrographic Office, and Mr. A. E. Sik of the Forecasts and Synoptic Reports Division, U.S. Weather Bureau, for assistance in assembling the ice data. We are particularly indebted to H. Wexler for his suggestions and comments.